

TELEMEMORY CONTROL SYSTEMS



/ **MOTOROLA**
Instrumentation and Control Inc.

TELEMEMORY® CONTROL SYSTEMS

A Foreword to Management

In energy distribution systems there is a particularly intimate relationship between the control requirement and the overall economics of operation. The two are inseparable; control efficiency is a prime determinant of profitability. For this reason, management cannot afford to concern itself solely with broad comparisons in evaluating supervisory control systems for purchase. Close attention should be directed to the details of system design and to basic design concepts, for these determine the performance and reliability not only of the control system, but of the distribution facility itself.

At the present time, for example, practically all supervisory control systems are of "modular" or "building-block" design. The advantages of this type of construction have been so well publicized that it is frequently assumed that modular design, in itself, offers an implicit guarantee of maintenance simplicity, ease of system expansion, and other equally desirable qualities.

This is gross oversimplification, of course. While modular construction does offer many benefits, it is not a cure-all for either the systems engineer or the user. Even with modular design techniques, systems still must be job-engineered to the individual application. The amount of special-case engineering involved is primarily dependent upon how well modular techniques have been applied.

The "traditional" approach to modular design is based on the use of single-function modules—i.e., individual component packages capable of performing only one discrete operation. In systems so designed, each logic circuit, for instance, is typically a separate circuit card. This technique provides flexibility of system configuration, but at the price of a number of serious drawbacks.

New design technique. The Motorola Telememory Control System is based on a new principle of modular design that obviates the disadvantages inherent in the older technique. Each major system function—transmission, encoding, decoding, etc.—is handled by a single consolidated unit. These units, called function channels, are individual circuit packages consisting of all the necessary logic and related circuitry to perform their respective jobs.

One obvious result of this design approach is simplification: there are far fewer component packages than in a conventional modular system. System design is similarly simplified. The channels are generically standardized and their interface relationships are fixed; they can be assembled to meet practically any given set of supervisory control requirements without elaborate systems engineering. This is not so with conventional systems, where complex interfaces can impose problems of impedance matching, critical lead length, and other difficulties.

The constancy of channel interfaces also obviates an important related problem: the need for built-in overcapacity to handle possible future expansion. When interface relationships are unpredictable, overcapacity is the one sure way to provide electronic "room" for additional system components.

With Telememory's fixed circuit parameters, add-on capability is inherent. Additional remote stations can be incorporated as needed, and the message length and structure can be modified to suit, just by adding new channels to the existing complement. The user does not have to buy more system capacity than is actually called for at the time of purchase.

Conceptual simplicity. A corollary advantage of function channel design is its intelligibility. System operation can be readily understood without an intimate knowledge of equipment circuitry because each channel's function is clearly spelled out. Trouble-shooting, for the same reason, is notably straightforward; the symptoms presented can be easily traced to a specific channel. In a conventional system, malfunctions cannot be so readily diagnosed; the source of a trouble may lie in any one of possibly dozens of identical modules.

Even from the few examples cited above, it can be seen that the generic label, "modular," is entirely without significance as a basis for system evaluation. The same is true of the term "solid state," which is often accepted as *de facto* evidence of system reliability. Solid state devices are generally more reliable than many other functionally comparable components, but the situation is far from cut and dried.

Again, the Telememory System is a case in point. Though nominally solid state, it actually uses relatively few semiconductor devices. All main-line logic functions are affected through magnetic logic circuits which, as explained opposite, are fundamentally different from the solid-state transistor-diode logic circuitry commonly employed. Moreover, where transistors are used in the system, they are operated on extremely short duty cycles—an important reliability-enhancing factor that would certainly not be apparent from the superficial description, solid state.

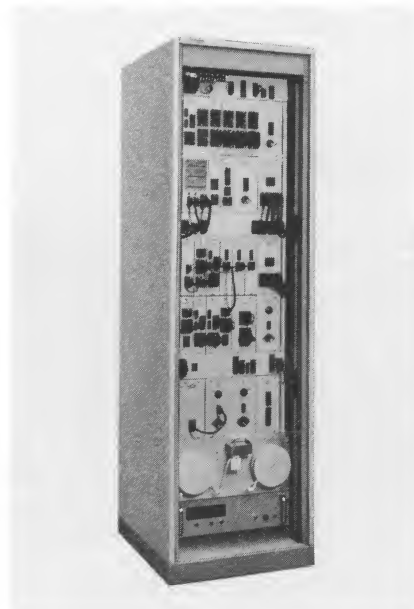
There are many other areas of difference between the Motorola design approach and conventional techniques. These will be evident from the detailed system description that follows. It will be noted, further, that the exposition in this brochure is more thoroughgoing than is customary for the industry. In Motorola's view, it is only through an examination in depth (of Telememory or any other supervisory control system) that a truly informed buying decision can be reached.

A new order of capability in remote monitoring and control through functional simplicity and magnetic logic

Function Channel Design—It is no overstatement to say that the integrated-function channel concept (see "Foreword," opposite) is a major advance in the state of the art of control system engineering. This unique circuit-packaging method is quite probably as important a development as was the original idea of single-function module packaging. In time it will no doubt become the standard design technique for the engineering of relatively complex control systems.

As implemented by Motorola, the function channel concept provides a degree of component standardization unprecedented in the field of industrial telemetry. Telemetry function channels are generically interchangeable, quantity-produced units. Each is a refined, optimized design—not a one-shot piece assembled from individual circuit modules for a particular system and application. Moreover, the interfaces between channels are fully standardized, so that interwiring is accomplished through simple cable-harnessed connections (see photo) on a direct one-to-one basis.

In fact, it is chiefly through manipulating the cabling scheme that Motorola achieves flexibility of system design. The standard function channels can be set up to accommodate diverse inputs and outputs, according to the way in which they are interconnected. A Telemetry encoder channel, for example, can be externally programmed to give whatever message structure is required, even though its internal circuitry is fixed. Such flexibility is advantageous not only in the initial design of a system; it provides the user with a built-in hedge against the possibility of future changes in operating requirements.



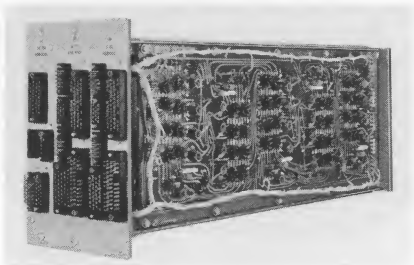
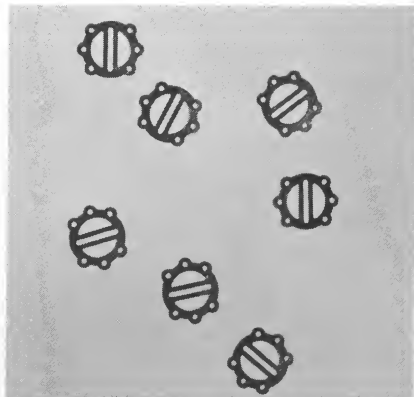
Multiaperture Ferrite Core Logic—Logic (signal-routing) functions are basic to the operation of all telemetry systems, and in the Telemetry Control System these all-important functions are handled by a new type of passive solid-state component: the multiaperture ferrite core.

The multiaperture core is the simplest logic element yet developed. An individual multiaperture core, with its integral windings, is capable of performing an entire logic operation within itself; each core, in effect, is a complete logic circuit contained in a single homogeneous device (see page 5). This is in marked contrast to diodes, transistors and other types of logic devices, which characteristically require networks of associated components to perform even the most rudimentary logic operations.

Because of the inherent simplicity of core logic, the Telemetry System is much simpler in circuit structure than comparable systems based on other logic techniques. It has fewer components and a considerably reduced number of solder connections—two factors which contribute much to the system's demonstrated long-term reliability.

Multiaperture cores, moreover, are among the most durable of electronic components. The ferrite from which they're made is a fired ceramic material, homogeneous in composition and immune to aging. The cores are not adversely affected by overloads and can withstand extremes of ambient temperature and humidity.

Intrinsic fail-safe operation is an important property of multiaperture cores. The cores will remember an input indefinitely, without standby power. After a power outage, they will return to operation in the previously set condition. The possibility of erratic control on restart is thereby eliminated—a particularly advantageous feature for unattended control equipment.



General description and scope of application

The Telemetry Control System is a digital telemetering system for centralized monitoring and control of remote distribution facilities, such as petroleum and natural gas pipelines, electric power substations, water conveyance networks, etc.

The system can comprise as many control points and remote stations as required. All systems, regardless of size, are built with generically standardized functional units (see pages 8, 9), which are combined in whatever number and configuration are necessary to meet the demands of a particular application.

Telemetry is compatible with all commonly used transmission media. It can operate over 15-cycle telegraph channels, teletype channels, telephone voice line, VHF or UHF radio, microwave, or power line carrier. Transmission speed, or bit rate, is field adjustable in two ranges, 10 to 160 pps and 40 to 320 pps.

The transmission keying technique employed is dependent upon the transmission medium selected. Frequency shift keying is used for voice-grade media; pulse duration keying for telegraph-grade media. (See page 7.) The system's keying units are plug-in assemblies and may be interchanged, if ever necessary, to accommodate a change from one class of transmission media to the other.

Capabilities

Monitoring Functions. There are two categories of monitoring functions: (1) equipment status reporting—pump on or off, circuit breaker open or closed, valve position, etc.; and (2) quantitative data acquisition—flow rate, totalized flow, liquid level, current, voltage, watts, vars, etc.

Status inputs are generally obtained from contact closures associated with the controlled equipment. Quantitative inputs are digitized from appropriate primary transducers.

Alarms. Automatic alarm indication can be provided for any remote station status or quantitative data inputs desired. Alarm display is a flashing-lamp presentation; this may be supplemented by an audible signal, at the user's option.

Control Functions. Basic control functions comprise the following: discrete

control; jogging control; and set-point control. Discrete control provides two-state control action—on-off, open-close, etc. Jogging control permits incremental positioning of the remote-controlled equipment. Increments are field adjustable. Set-point control gives proportional action based on a numerical value. The set-point is transmitted as a digitally coded message; this is converted at the remote to an analogous current, voltage or pneumatic signal appropriate to the local controller.

Local Closed-Loop Control. Remote stations can optionally incorporate closed loops for local automatic control of both primary variables and computed variables, such as mass flow. Motorola can provide the necessary analog equipment from its comprehensive line of Veritrak* solid-state instrumentation. (Descriptive literature is available from any field office or from the main office in Phoenix.)

Operational Modes

The Telemetry System can be supplied for either quiescent or dynamic (scanning) operation. The choice of mode is a customer option and is primarily determined by application requirements.

Quiescent Mode. In the quiescent mode transmissions are made on an as-needed (i.e., non-programmed) basis. The central station operator may interrogate the remote stations at any time to update information, and he may issue control commands whenever necessary. The remote stations transmit when interrogated or when there is an alarm or change of status.

Alarms and status changes are automatically reported. This is accomplished through a trip detector circuit within the status-input Repeater Channel at each remote station (see page 9). The trip detector monitors contacts reflecting the status of all the controlled devices. When any device changes state, the trip detector automatically causes the transmission of a new, updating message.

Remote stations can also be equipped to report automatically whenever a quantitative input, such as pressure or flow, deviates from normal by a predetermined amount or when the rate of such change is greater than normal. In both cases,

the remote will read the quantities involved and transmit them to the central station.

Special message traffic control is incorporated in quiescent systems to handle the possibility of simultaneous or overlapping transmission by two or more spontaneously reporting remotes. When such a condition occurs, the central station rejects the "smeared" message and automatically instructs the remotes involved to retransmit in sequence.

Dynamic Mode. In the dynamic mode the central station continuously interrogates the remote stations and the remotes reply in turn. A Scanner/Encoder Channel at the central station controls the sequence of interrogation; it can be programmed to scan the remotes in any desired order.

The scanning program can be interrupted at any time to permit the central station operator to issue control commands. Control pushbuttons provide automatic program interruption and reinstating.

Message traffic control is implicit in the mode of operation. Overlapping transmission cannot occur because the remote stations transmit only when interrogated.

Simultaneous Multi-Point Data Acquisition

This option provides a means for simultaneous acquisition of data from multiple remote sources. The option is particularly desirable for systems that are to be operated under computer control. It is also applicable where accounting procedures require that billing data be accumulated on an exact common time base, as in KWH telemetering.

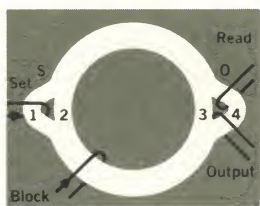
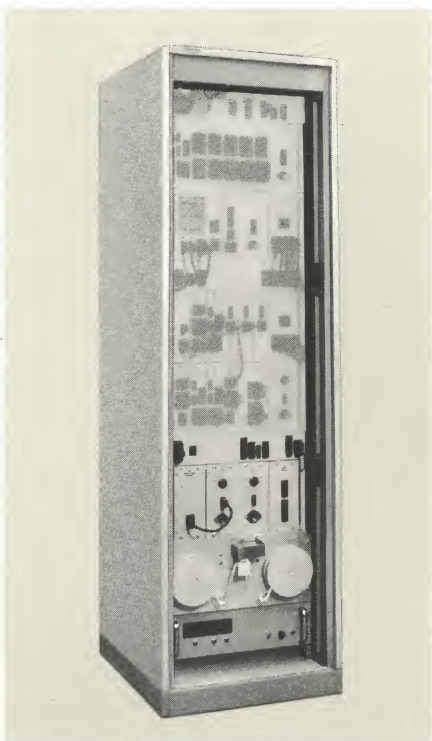
Simultaneous acquisition is accomplished through what is called a "freeze" technique. When data are to be read—i.e., at the start of a logging cycle—the central station transmits an "all station freeze" command to the remotes. The freeze command causes all the various data inputs throughout the system to be digitized and stored at the same instant. The data are then transmitted sequentially to the central station and are logged with a common time reference. Since measurement is simultaneous for the entire system, the validity of the logged data will not be affected by any scanning or communications delays that might be introduced.

Data Logging

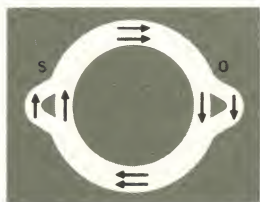
Data logging can be incorporated in any Telememory System, quiescent or dynamic, at the user's option. It can be included at the time of original purchase or added at any time thereafter; the implementing components (see page 9) are plug-in units with inherent add-on capability.

The Telememory logging method is unique in that it operates through a stored, rather than wired-in, program. The storage medium is a punched tape. The tape controls both the acquisition of data and the format of the log. It also controls the operation of the tape reader, by providing instructions for search and reset. Any or all of these functions can be changed at will, and the program can be expanded as needed, simply by writing a new tape. Such complete flexibility is not possible, of course, with a wired-in program, which requires the alteration or addition of circuits to accommodate the insertion of new program steps.

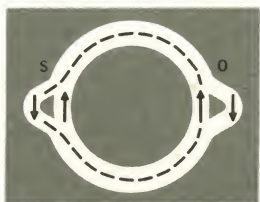
The tape reader has an individual-station search mode; through manipulation of control inputs it can either generate a complete system printout or selectively log one remote station. The program tape is extremely durable; made of Mylar, it is rated at over 4 million readings.



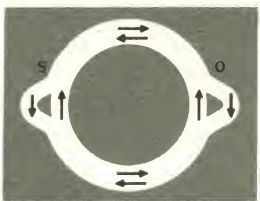
A



B



C



D

Multiaperture Core Logic: How it Works

The basic operating principles of multiaperture core logic can be illustrated by examining the functioning of a simple gate core (Figure A).

The core has no external components. As shown, it has three apertures and four separate windings, one each for Block, Set, Read, and Gate (the output) functions. A Block pulse will close the gate and a Set pulse will open it when certain conditions are met.

The core is blocked by the application of a Block pulse to the large center aperture. The pulse is fixed at a current level sufficient to produce a coercive force of approximately two times the magnetization threshold of the ferrite core material.

The Block pulse saturates the core and causes its flux pattern to become essentially uniform, as shown in Figure B. If a Read pulse is introduced at aperture O when the core is in the blocked state, it will be unable to produce a usable output signal across the output winding. This is because both available legs of the flux path around aperture O are already saturated by flux established in opposing directions; the magnetic force of the Read pulse is blocked. The saturated flux path, in effect, acts as an air gap that minimizes transformer coupling to the output winding.

The core is unblocked by the application of a Set pulse at aperture S. The current level of the Set pulse is made strong enough to cause flux reversal along the path indicated by the dotted line in Figure C. Since the new flux path includes one leg of aperture O, a new condition is established in which the flux paths are in the same direction around aperture O. Under this condition the simulated air gap between the Read and Output windings is removed; the Read pulse is now able to induce a signal in the Output winding by simple transformer coupling principles.

The output of one multiaperture gate core can be coupled to the Set input of another to provide a propagated gating function. In this manner it is possible to construct elaborate logic circuits composed solely of multiaperture cores without any interstage amplifying devices.

Special Feature: Self-Checkout

A simple test set, specifically developed for the Telememory System, permits personnel of routine technical skills to checkout and troubleshoot remote and central station equipment without extensive special training.

The test set is available as an option. It consists of a message-programming unit and a small strip-chart recorder. These can be supplied either for portable use or as integral components installed in the station equipment cabinet.

The programming unit, by means of manually set selector switches, provides simulated command messages. The recorder shows the responding message. The response of the recorder is sufficiently fast to handle the most commonly used pulse rates, which are generally below 100 pps. For pulse rates above that level, a conventional oscilloscope, with a medium-persistence crt, can be used for the same function.

Coding Techniques

In order to obtain maximum efficiency in handling the several types of digital information required for monitoring and control, the Telememory System employs three different binary codes. Each code has a specific area of use, but all are treated identically in the transmitting and receiving portions of the system. All, in addition, are incorporated in the message structure on the basis of five-bit groups, with the result that shift registers and other sub-channel entities are standard throughout. The codes and their functions are as follows:

2/5 Code. The 2/5 (two out of five) code is based on a five-bit group in which two of the bits are always binary "1" and the remaining three, binary "0". The main advantage of this code is the ease with which it can be decoded by simple coincident-current techniques.

Although coincident-current error detection can be used with any two-out-of-n scheme, the five bit grouping offers a worthwhile corollary advantage. The total number of valid code combinations obtained with the 2/5 code is ten. By the simple expedient of assigning sequential decimal equivalents from 0 through 9, the 2/5 code is made functionally compatible with the decimal number system.

The 2/5 code is used for remote station and point address, remote sta-

tion identification (incoming messages to the central), and control commands.

Binary Coded Decimal. Binary Coded Decimal (BCD) coding is used for the transmission of quantitative data from remote stations. The scheme employed is the conventional 8-4-2-1 arrangement, with a fifth "0" bit added to maintain the system's standard five-bit grouping. BCD is used here because it is compatible with the input requirements of most digital display devices, logging equipment, and data-processing computers.

BCD and 2/5 code groups are referred to as "digits" because each five-bit group is equivalent to one discrete unit or decimal digit of information.

Unitary Code. The term "unitary" designates a code structure in which each message bit, by itself, represents a discrete item of information.

The unitary code is used for reporting equipment status in remote-to-central messages. Each item of equipment is assigned a specific bit position, and its status is encoded in straight binary code, as either a "0" or a "1" bit. Since the status information is inherently binary (two-state) in form — e.g., on-off, open-closed, alarm-normal, etc. — this technique of binary coding is a most efficient method of handling status and alarm data.

To achieve conformity of message

processing, unitary bits are inserted into the message structure in groups of five. Each bit nevertheless retains its discrete, independent, information value.

Message Structure

The general patterns of message construction are essentially the same for all Telememory Systems. Within the standard formats, however, message length and configuration will vary according to the size of a system and the type and quantity of information to be transmitted.

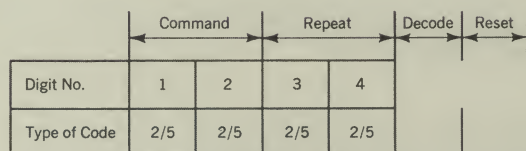
Two generically different message structures are used, one for central-to-remote messages and one for remote-to-central. Both are organized on the basis of five-bit code groups, as noted previously. Message bits are encoded five at a time and are then transmitted serially, one group after another. At the receiving station messages are likewise decoded in five-bit segments.

Central-to-Remote Messages. Point address and station address message structures are both used in Telememory Systems. The choice of addressing technique is generally a function of the size of a given system. Smaller systems will normally employ point address alone; large systems will typically use station and point address.

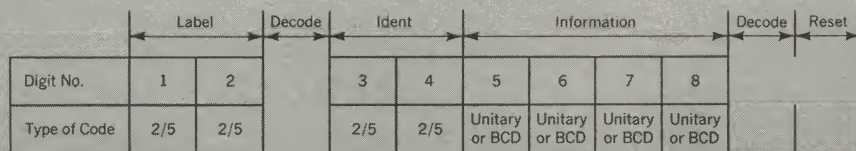
Control commands are encoded in 2/5 code and, for security, are transmitted as redundant messages (Figure A). The number of digits used in the command is determined by the number of points to be controlled. The two-digit structure shown will provide 100 unique commands, since each 2/5-coded digit has ten possible decimal equivalents. A three-digit command, similarly, will provide a capacity of 1000 points.

The command message is terminated by two neuter slots or "holes," each of which is of one-digit (five bits) duration. The first five-bit neuter serves as the signal to decode the message; the second resets the decoder, clearing it to receive a new message.

The message structure is individually adjusted to the requirements of each remote and need not be the same for all stations in a system. A branching or label decode technique can be used to provide increased in-



A Central-to-Remote Message Structure



B Remote-to-Central Message Structure

formation capacity where necessary. For example, when station and point address are employed, the received message is decoded by two (or more) decoder channels. The first decoder channel recognizes and decodes the station address; the second extracts the point address. The message words are separated by five-bit neuter holes, and these cause each decoder in turn to decode the preceding information. Any number of decoders can be used. Thus, with the branching technique any required message structure can be implemented (or altered) with standard decoder channels of appropriate capacities.

Remote-to-Central Messages. As above, the message length is adjusted to the requirements of each remote station.

A remote-to-central message opens with a repeated label digit, which identifies the message type: status, data, or logging (Figure B). This is followed by a decode hole that causes the message label to be decoded. The remainder of the message consists of a two-digit data or status identity and the information itself. The two-digit data or status "ident" serves to steer the information that follows to appropriate displays or to the logging equipment, as the case may be.

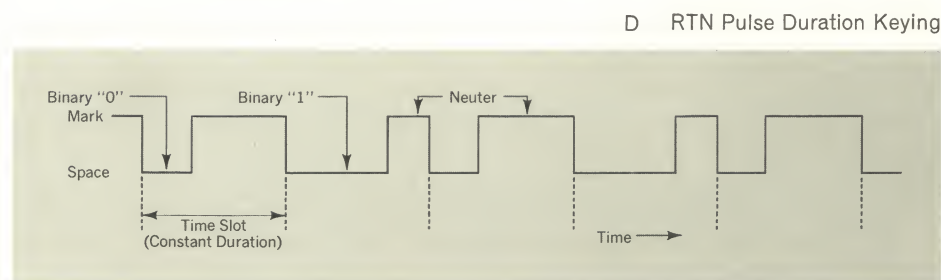
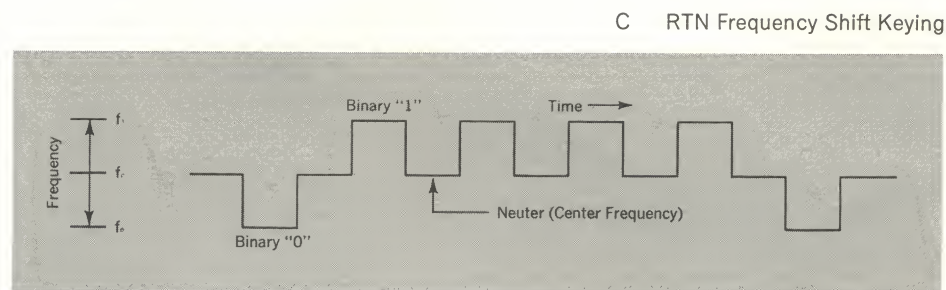
Message Security

Message security in the Telememory System is thorough. It comprises a number of complementary message-checking techniques to prevent a receiving station from implementing spurious messages. Two levels of security are used; application is determined by the class of message.

Command Messages. Control commands are subjected to maximum error-detection security. A total of four security checks effectively preclude the actuation of any false commands that might occur.

1. Redundant Message; Bit-by-Bit Comparison. Two identical messages are sequentially transmitted for each command; the two must coincide completely, bit by bit, to be recognized as valid. This makes it virtually impossible for random noise to generate a false command, since the statistical properties of noise are entirely different from those of the message itself.

2. Bit Counting. Each message must



contain a fixed number of bits. Too few or too many bits will cause rejection.

3. Self-Synchronizing Operation. The clocking or synchronizing information for the receiving station is implicit in the return-to-neuter keying technique employed (see below). Errors caused by out-of-sync operation are thereby obviated.

4. Iterative Output. An iterative network placed between the command output and interposing relays prevents the energizing of more than one relay at any given instant. If equipment malfunction should cause two simultaneous command outputs, power will be immediately removed from all interpose relay coils so that no control action will take place.

Status and Data Messages. Bit counting, item 2 above, and self-synchronizing operation, item 3, are applied to remote-to-central messages. In addition, the message-type label is redundantly transmitted as explained in item 1.

Keying Techniques

The transmission of binary-coded (unitary, 2/5, BCD) messages is accomplished with either of two pulse-keying techniques: frequency shift keying (FSK) or pulse duration keying (PDK). FSK is used preferentially for applications involving higher transmission speeds because of the superior signal-to-noise ratio that can

be obtained. PDK is used for systems where a DC telegraph channel is to be employed.

The Telememory System's FSK scheme (Figure C) uses a three-level transmission in which constant-duration pulses key tone-carrier frequencies. There are three pulse identities: binary "1," binary "0," and neuter. Neuter is established as the center frequency. In an FSK transmission neuter pulses are placed between the binary-bit pulses in a bit-neuter-bit-neuter pattern. This arrangement of regularly recurring neuter pulses makes the clock rate implicit in the message, with the result that the transmitting and receiving stations are automatically locked in step throughout the transmission. The inherent synchronization provided by return-to-neuter transmission obviates the possibility of message errors caused by out-of-sync operation.

In pulse duration keying, return-to-neuter transmission is also used, and messages are similarly composed of "1," "0," and neuter identities (Figure D). The "1" and "0" bits are represented by long and short circuit interruptions, respectively. Neuter is represented by current flow in the telegraph loop.

Recognition of bit identities is accomplished by comparing the length of each circuit interruption with the constant length of the bit frame containing it.

SYSTEM OPERATION

Central Station

The top photo-diagram shows the complement of function channels constituting a basic Telemetry central station. This channel complement is common to all systems; it is the nucleus of the central station structure to which other channels may be added as required. The number of Encoder and Decoder Channels used in any given system, for example, is determined by the message length and structure necessary to handle the system's particular monitoring and control functions. The function channels, themselves, are all standard components which are "adjusted" to individual system parameters by means of external plug-programming.

Operation is as follows:

To initiate a message, the central station operator first actuates the appropriate command/address pushbutton (or selector switch) on the control console. Then, to implement the command, he depresses an "Actuate" button. This activates the Encoder Channel. The Encoder is an electronic scanner with externally programmable stepping. The strapping of the Encoder's program plug determines the utilization of the scanner steps which, in turn, establishes the message structure.

The Encoder enters the message, five bits at a time, into the shift register of the Trabic* (Transmitter, Basic) Channel. The Trabic Channel encodes the message in 2/5 code or BCD, as directed by the programming of the Encoder output. It then shapes the code pulses for transmission and inserts the clocking (keying rate) information into the message. From the Trabic, the message is routed bit-by-bit to the Tone Unit (or DC Keying Unit, in a DC-carrier system) for transmission to the remote station.

Incoming messages from remote stations are coded with a long neuter pulse at the beginning. The long neuter opens the

squench on the central station Tone Unit, permitting the pulse train to enter the Rebic* (Receiver, Basic) Channel. The Rebic extracts the clock rate from the message and, in addition, provides decode and reset decisions for the Decoder Channel.

The Decoder Channel stores the incoming message and checks it for validity. If the message proves invalid, the Decoder signals the Rebic, which actuates an output contact to indicate an invalid message on the console display. If the message passes the security checks, it is decoded and routed to the Command Channel.

The Command Channel is essentially a pulse amplifier. Its function is to lengthen the message pulses sufficiently to operate the electromechanical devices in the Repeater Channel.

The Repeater Channel serves as the interface between the electronic circuits and the contact-making indicating circuits. Its output, in the form of contact closures, is fed into the Point Logic Channel. The Point Logic Channel, through individual latching circuits, routes the message information to the appropriate lamp displays.

Status changes reported in the incoming messages are indicated by flashing-lamp presentation. Alarms are similarly indicated and, at the user's option, may also be annunciated by an audible signal.

The Smear Encoder Channel is used only in quiescent systems. It automatically commands the remote stations to retransmit when an invalid message is received (see page 4).

In the dynamic mode, remote station interrogations are continuously and automatically generated by the Scanner/Encoder Channel. Incoming messages are processed in the same way as in the quiescent mode.

There is provision for interrupting the scanning program to insert control action (see page 4).

Logging Option

A central station which includes data logging will comprise the additional function channels and peripheral equipment shown.

Logging cycles may be either manually or automatically initiated. The Tape Reader (see page 5) issues the logging commands. The commands are transferred directly into the shift register of the Trabic Transmitter, with timing developed through the Encoder Channel.

Reply messages from the remote stations are stored in the logging Decoders. Under control of the Tape Reader, the received data are subsequently routed, digit-by-digit, from the

Decoders to the logging output writer. At this point the data are in 8-4-2-1 code.

The Tape Reader also performs two other functions. It issues instructions for real-time data (from the digital clock) to be inserted in the log, and it controls the log format.

As indicated in the diagram, the Matrix Channel is used only in conjunction with an IBM logging typewriter; it converts the Tape Reader's output to IBM printer code. The Reader's output is directly compatible with the Friden Flexowriter and other devices that use eight-hole tape.

Remote Station

Like the central station, the remote stations in a Telemetry System are structured in accordance with the functions they are to perform. The diagram shows the remote station channel complement required for implementing the main, basic types of input and output functions.

From the standpoint of internal information-processing techniques (data acquisition, encoding, decoding, etc.) remote station operation is essentially the same in both the quiescent and dynamic modes. The channel complement is therefore the same for both modes, with the notable exception of the Smear Timer Channel. This channel is used only in quiescent remote stations. Its function is to provide a time-delayed retransmission when the central station receives an invalid message (see page 4).

The various inputs at a remote are generically segregated and encoded, but all are processed for transmission by one common Trabic Channel.

Status and alarm inputs are derived from contact closures (or openings) through the interface of a Repeater Channel.

Quantitative data may be acquired either from analog transducers (pressure transmitters, flow-meters, transformers, etc.) or pulse-output measurement devices (contact-making PD meters, watt-hour meters, etc.)

Analog information, in the form of DC voltage or current, is

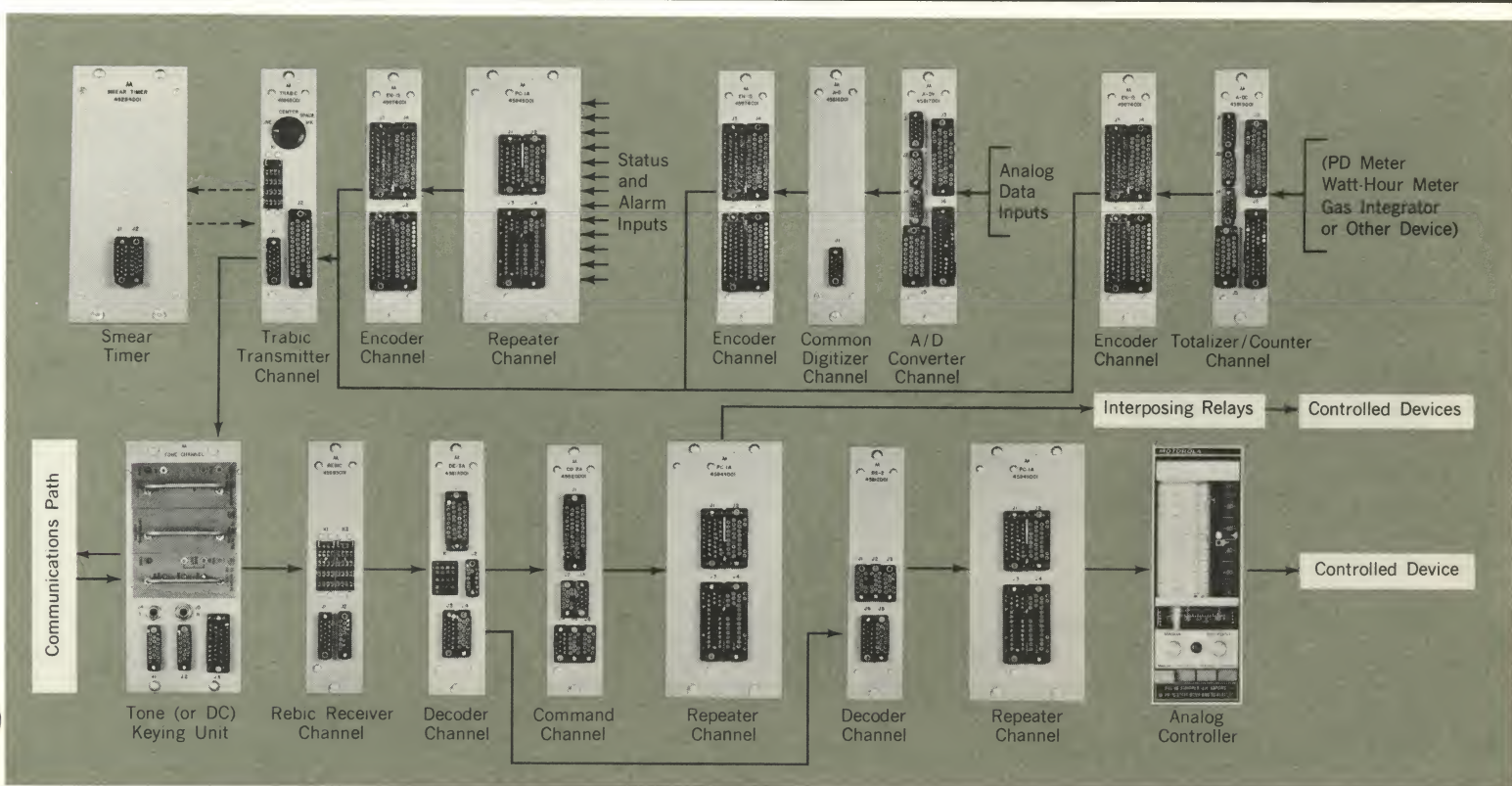
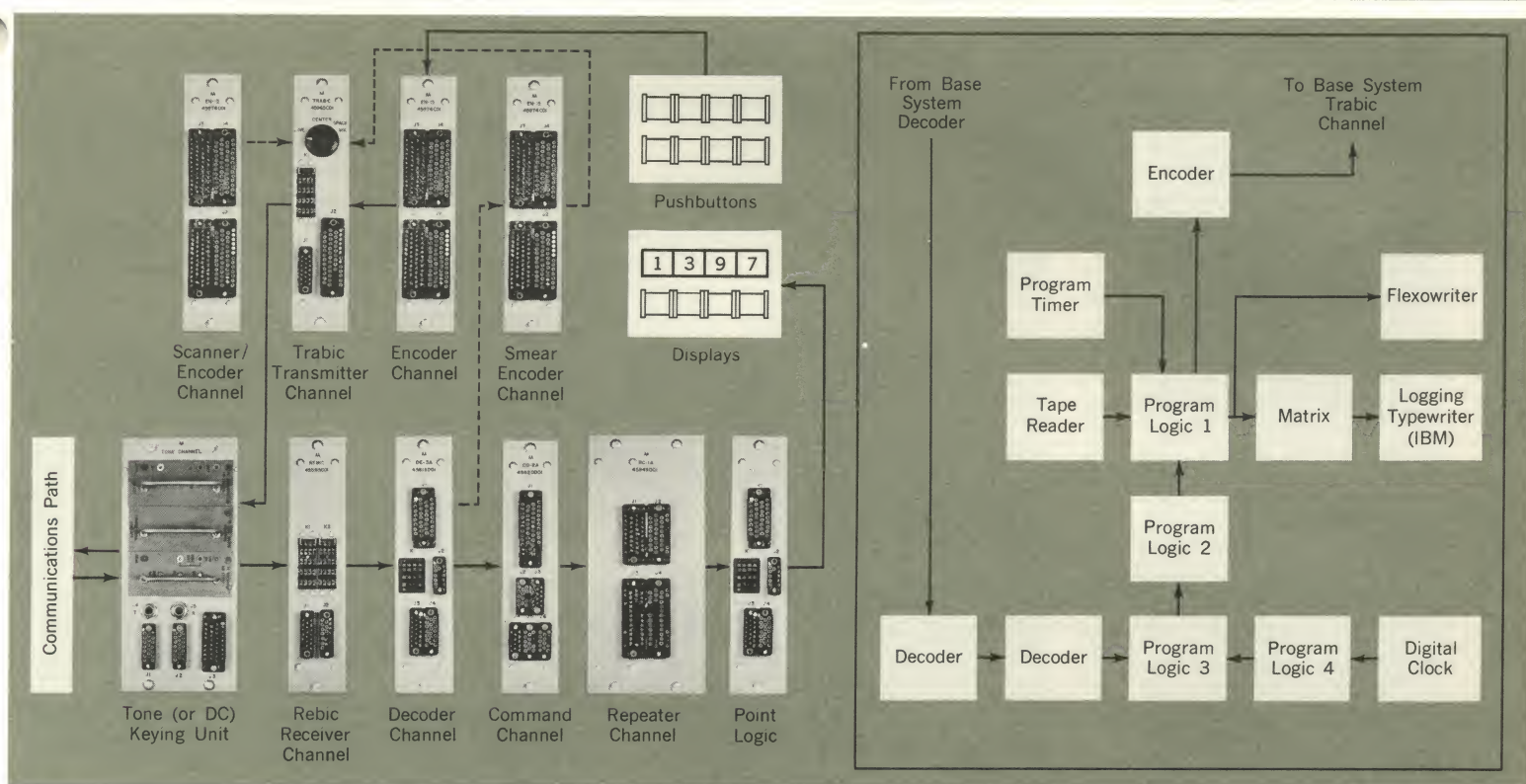
digitized by an Analog-to-Digital Converter Channel. (The Digitizer Common Channel develops timing and reference voltage signals for the A/D Converter.)

The output of contact-making meters is stored and counted by an Accumulator Channel. Counting is done in 8-4-2-1 code, which is suitable for direct transmission to the central station.

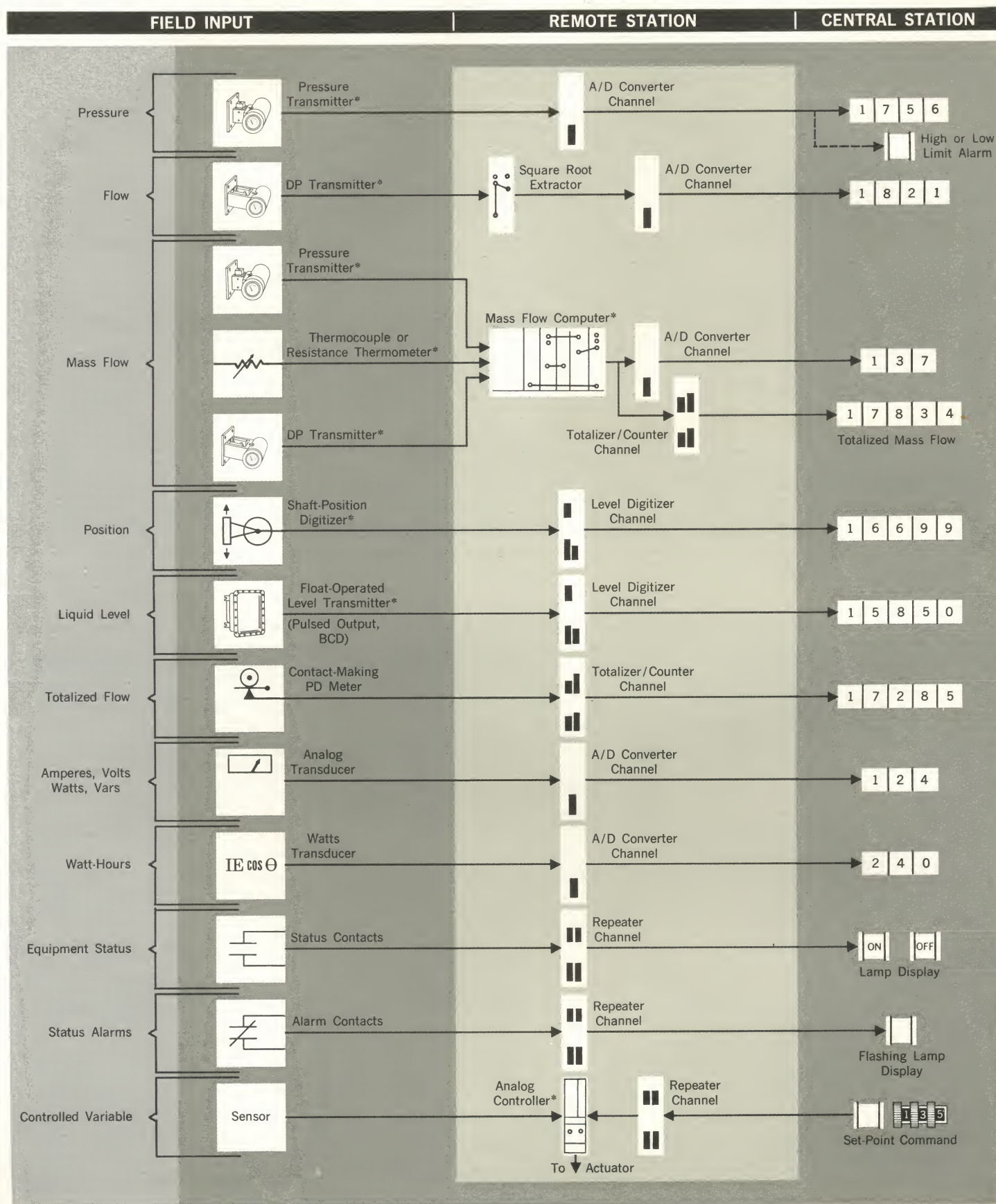
All incoming messages to a remote are routed through a common Rebic Channel and one or more Decoder Channels. The number of Decoders used depends on the message structure, which can be unique for each remote (see page 6).

The first Decoder accepts the control commands and, after checking them for validity, steers them to the Command and Repeater Channels. The channels perform essentially the same functions as their counterparts at the central station. The commands are effected through interposing relays associated with the various items of controlled equipment.

The primary Decoder is programmed to route set-point commands (coded in BCD) to a second Decoder Channel. Here, the set-point is converted to an analog signal by a special digital-to-analog Repeater Channel. The analog control signal serves as the set-point for a controller operating in a local feedback loop. The controller may be a Motorola Veritrac instrument or a customer-supplied unit with provision for external set-point input.



REPRESENTATIVE SYSTEM OPTIONS



*Indicates Motorola instrumentation available as customer option

CONTROL FUNCTIONS



Discrete Control Provides on-off control action. Can be used to raise and lower sluice gates, open and close valves, start and stop pumps, compressors, etc., and open and close circuit breakers and switchgear. Output command is momentary contact closure of a nominal one second duration.



Jogging Control Provides on-off commands with predetermined duration from one second to 30 seconds for jogging or inching control. Duration of commands is individually field adjustable.



Digital Set-Point Adjusts set-point of remote-station local control loop(s) to provide proportional control of any desired variable(s).

OPERATING FUNCTIONS



Drum Switch Control Selection Generally used in larger systems; optional in any size system. Revolving drum-type switches develop control commands. Operator rotates the drum to select appropriate station, equipment, and operation (open, close, etc.), which appear in the associated indicator windows.



Pushbutton Control Selection Two options are available. One option provides three groups of pushbuttons for selection of station, equipment, and control operation (on, off, etc.) respectively. Second option provides one pushbutton for selection of both equipment and control command—e.g., "Start Pump 2," "Read Tank 5 Level," etc.



Actuate Causes command to be transmitted after operator has selected station and/or point address(es).



Reset Permits operator to clear previously set commands from console in the event of selection error.



Command Lock Disables all control buttons, to prevent accidental operation.



Lamp Test Lights all lamps on console for testing.



System Update Permits operator to initiate automatic interrogation of all remote stations in system between scheduled logging cycles.



Data Update Permits operator to interrogate a remote station at any time for an update of any quantitative-data or status input.



General Specifications

STATUS AND ALARM INPUT

Customer-furnished Form A or Form B contacts capable of carrying 50 ma at 24 VDC with maximum loop resistance of 50 ohms.

CONTROL OUTPUT

Standard Control Output: Form A contacts rated at 24 VDC, 3 amp, inductive load.

Heavy-Duty Control Output: Form A contacts, rated at 25 amp, 115 VDC or 1 HP at 115/230 VAC.

TRANSMISSION

Medium: Telephone voice line, VHF or UHF radio, microwave channel, 15-cycle telegraph channel, teletype channel, power-line carrier.

Keying: Frequency shift keying (voice-grade media); pulse duration keying (telegraph-grade media).

Bit Rate: Field adjustable in two ranges: 10 to 160 pps and 40 to 320 pps.

TONE TRANSMITTER AND RECEIVER

Frequency Channels: Between 1200 and 5000 cps.

Transmitter Output Level: -25 dbm to +1 dbm.

Transmitter Output Impedance: 600 ohms.

Receiver Input Level: -30 dbm, minimum.

Receiver Input Impedance: 600 ohms.

DC KEYS

Transmitter Output: Transistor drive to standard Western Electric No. 255 A relay (relays supplied as optional extra).

Receiver Input: Dry Form A contact capable of carrying 10 ma at 12 VDC.

CONTROLS AND DISPLAYS

Select and Command Controls: Backlighted pushbuttons; drum-type selector optional.

Status Display: Integral to pushbuttons, segmented for multiple status indications; separate display optional.

Quantitative Data Display: Projection-type 3-, 4-, or 5-digit indicator; mechanical display optional.

PHYSICAL

Circuit Construction: Standard function channels; heavy-duty etched circuit board secured to slide-out frame; all interconnections and program plugs front accessible.

Channel File: 9 x 19 x 20 inches; accommodates up to 8 function channels.

Channel Cabinet: 77 x 23 x 26 inches; front access door.

Control Console: Desk-type unit, as illustrated; table-top console optional.

ENVIRONMENTAL

Ambient Temperature: -4 F to +131 F (-20 C to +55 C).

Relative Humidity: Up to 100%.

POWER REQUIREMENTS

Central Station: 24 $\pm$ 4 VDC @ 2 amp nominal; actual power drain is a function of station size.

Remote Station: Same as for central station.

TELEMEMORY CONTROL SYSTEMS

FIELD OFFICES

Inquiries concerning Telememory Control Systems should be directed to the nearest field office or to: Motorola Instrumentation and Control Inc., P. O. Box 5409, Phoenix, Arizona 85010. Telephone: (602) 945-6311.

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